



Long Term Resource Monitoring Program

## **Program Report 2002-P001**

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### **Workshop Report**

# **Recommended Investigations of Sediment Transport and Deposition for Predicting Future Configurations of Upper Mississippi River System Channels and Floodplain**

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**September 2002**

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**20021129 071**

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# **Workshop Report**

## **Recommended Investigations of Sediment Transport and Deposition for Predicting Future Configurations of Upper Mississippi River System Channels and Floodplain**

by

Robert F. Gaugush and Daniel B. Wilcox

Final Report to  
U.S. Army Corps of Engineers  
Rock Island, Illinois

for

Long Term Resource Monitoring Program  
Scope of Work Number 6.3  
(Sediment and Geomorphology Work Plan)

September 2002

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**Suggested citation:**

**Gaugush, R. F., and D. B. Wilcox. 2002. Recommended Investigations of Sediment Transport and Deposition for Predicting Future Configurations of Upper Mississippi River System Channels and Floodplain. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, September 2002. LTRMP 2002-P001. 5 pp. + Appendix.**

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## Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the Environmental Management Program for the Upper Mississippi River System. The LTRMP is implemented by the Upper Midwest Environmental Sciences Center of the U.S. Geological Survey, in cooperation with the five Upper Mississippi River System states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin), with guidance and Program responsibility provided by the U.S. Army Corps of Engineers.

The mission of the LTRMP is to provide decision makers with information to maintain the Upper Mississippi River System as a viable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products.

This report supports two tasks in the LTRMP Operating Plan: Task 1.2.1.2, *Select Processes for Research*, and Task 1.2.1.3, *Establish Experimental Design*, under Strategy 1.2.1, *Determine Effects of Sedimentation and Sediment Transport Processes on the Upper Mississippi River System Ecosystem*. This workshop report was developed with funding provided by the Long Term Resource Monitoring Program.

# Workshop Report

## Recommended Investigations of Sediment Transport and Deposition for Predicting Future Configurations of Upper Mississippi River System Channels and Floodplain

by

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### Background

The fluvial processes of sediment transport and alluviation determine the configuration of the channels and floodplain of the Upper Mississippi River System (UMRS). This configuration, in turn, provides the physical template for the mosaic of habitats in the system. Previous studies of sediment and sediment processes in the UMRS have addressed many topics but have not produced quantitative and spatially complete estimates of changes in the geometry of the UMRS channels and floodplain. This information is needed to predict conditions in the river under various management alternatives and thus guide the development of plans for managing the riverine ecosystem. In an attempt to define these information needs, a Sediment Transport and Geomorphology Working Group was convened in 1994 to develop a detailed description of activities needed to understand sediment transport processes and the changing geomorphology of the UMRS.

The findings of this initial working group were summarized in a technical report (Gaugush and Wilcox 1994) that identified nine overriding tasks to be addressed to meet the information needs in this area. In brief, those tasks were as follows:

1. Literature review.
2. Compilation and review of existing hydraulic, sediment, and geomorphic data.
3. Obtain floodplain elevation data.
4. Map the geomorphology of the UMRS floodplain.
5. Establish an expanded sediment monitoring network.
6. Estimate tributary sediment discharge.
7. Investigate and quantify sediment transport and depositional processes within the UMRS floodplain.
8. Backwater areas sediment budgets.
9. Synthesis and estimation of future configuration of UMRS channels and floodplain.

Since the development of that planning document, Long Term Resource Monitoring Program (LTRMP) sediment- and geomorphology-related work—including bathymetric surveys, development of GIS databases for land use/land cover and aquatic areas, and initiation of monitoring of the inflow and export of suspended sediment from selected navigation pools—has progressed. The U.S. Army Corps of Engineers (Corps) conducted an assessment of the cumulative effects of the navigation system as part of the Upper Mississippi River-Illinois Waterway Navigation Study, which included a review of historical geomorphological changes, an update of the sediment budget for a series of navigation pools of the Mississippi River, and a forecast of river conditions. In August 2000, a second Sediment Transport and Geomorphology Working Group was formed to review progress and to reexamine the proposed directions for research.

### **Approach**

The second working group revisited the tasks identified by the first working group, identified subsequent work performed under each of the tasks since the first workshop, and made recommendations for future investigations. Of primary concern to the second working group were research and monitoring activities carried out by the LTRMP and those conducted by the Corps in support of their navigation study.

#### ***Task 1. Literature Review***

This task was intended to provide a thorough review of the scientific literature pertaining to sediment delivery, transport, and depositional processes within the channels, floodplain, and geomorphology of the UMRS. This task has been completed and an annotated bibliography produced (DeHaan 1998).

#### ***Task 2. Compilation and Review of Existing Hydraulic, Sediment, and Geomorphic Data***

The objective of this task was to compile existing data on historical land use, upland erosion, sediment transport and deposition, hydraulic conditions, and geomorphology of the UMRS. Much of this task has been accomplished as part

of the Corps' navigation study. The second working group recommended that the report be made available through the U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC) Web site.

The second working group strongly recommended that UMESC assume the role of data curator as part of its LTRMP responsibilities. Whereas it was recognized that the LTRMP has done well in managing and serving their own data, the group identified a significant need for the LTRMP to provide these same services for non-LTRMP data. In particular, some historical data that do not exist in electronic format may be lost as investigators retire.

An example is the Sediment-Contaminant Database for the Upper Mississippi River and Selected Tributaries, a database recently compiled by the UMESC and the University of Wisconsin-La Crosse, River Studies Center with funds from the U.S. Environmental Protection Agency and the U.S. Geological Survey. This database will facilitate the assessment of riverine contamination, increase the availability of sediment-contaminant data, and facilitate management and scientific efforts related to contaminated-sediment issues in the river system (Bartsch et al. 2000). The sediment-contaminant database is available on the UMESC web site <[http://www.umesc.usgs.gov/data\\_library/sediment\\_contaminants/sediment\\_contaminant\\_page.html](http://www.umesc.usgs.gov/data_library/sediment_contaminants/sediment_contaminant_page.html)>.

#### ***Task 3. Obtain Floodplain Elevation Data***

This task was envisioned as the conduct of a comprehensive elevation survey of the UMRS floodplain and the development of a GIS database of the floodplain elevation data. The Corps and the UMESC are jointly investigating the use of a LIDAR (LIght Distance And Ranging) survey to obtain these data with funding provided in part by the LTRMP.

The second working group stressed that this remains a critical information need. In particular, the bathymetric data already collected by LTRMP should be linked to data above flat pool elevation. The data presently available are limited to 5-foot contours provided by digital elevation models, these



data simply do not have the required resolution and accuracy needed for river management and assessment.

#### ***Task 4. Map the Geomorphology of the Upper Mississippi River System Floodplain***

The purpose of this task was to develop a comprehensive set of maps of the geomorphology of the UMRS floodplain. Little work has been done on this task, primarily due to lack of the required floodplain elevation data mentioned in Task 3. The St. Paul District of the Corps has, however, produced some geomorphological maps for pools in their district primarily for use in archaeological investigations.

#### ***Task 5. Establish an Expanded Sediment Monitoring Network***

The objective of this task was to establish a series of elevation survey transects, properly monumented and documented for long-term monitoring of sedimentation in the lower reaches of tributaries and at key locations along the UMRS. To a limited extent, this task is being carried out and reported (Rogala and Boma 1996).

The working group recommended that this effort be greatly expanded and approached in a more systematic manner. For example, historical siltation surveys (elevation transects across the mouths of most tributaries) that were performed by the Corps before impoundment (in the late 1920s and early 1930s) could be rerun to document changes in elevation since impoundment.

The working group also identified the need for a qualitative system model that could deal with the problem of scale in a hierarchical manner. Primary issues that could be addressed by such a model would include sediment, climatological factors, engineering alterations to the system, and basin hydrology. Such a model would facilitate the planning process for the Environmental Management Program's Habitat Rehabilitation and Enhancement Projects that are now evolving toward a pool-scale model.

#### ***Task 6. Estimate Tributary Sediment Discharge***

This task was originally envisioned as a geospatial investigation in which UMRS tributary watersheds would be classified by their size, hydrology, land use, and geomorphic characteristics. The goal, by relating known information about sediment delivery to such watershed characteristics, was to estimate sediment delivery from unsampled watersheds. Some of this work is ongoing, but is largely limited to estimating nutrient and sediment delivery to the Mississippi River in relation to Gulf hypoxia.

#### ***Task 7. Investigate and Quantify Sediment and Depositional Processes within the Upper Mississippi River System Floodplain***

This broad task was developed to address the fundamental need to understand the basic processes of sediment transport and deposition within the UMRS. Three subtasks related to wave effects, resuspension of sediment, and bedload transport and deposition were specifically identified.

Considerable activity has been directed at this task. Sediment budgets for Pool 13 and the La Grange Pool were estimated (Gaugush 2000). Long-term average sediment budgets for Pools 11–26 were derived as part of the Corps' Cumulative Effects Study (WEST Consultants, Inc. 2000). A relatively simple model of wind and wave relations was developed (Chamberlin 1994), as well as a GIS model describing the distribution of wind fetch for UMRS pools (J. T. Rogala, USGS-UMESC, La Crosse, Wisconsin, personal communication). Bed material maps for Pools 4 and 8 were developed with the use of an in-situ sediment penetrometer (Rogala 1996).

The working group identified the need for further studies directed at the development of a GIS database of bed material for the UMRS. This database would be composed of bed material coverages (maps of sediment types for channel and off-channel areas) for the UMRS. The working group also identified the need for further research estimating transport of bed material.

### **Task 8. Backwater Areas Sediment Budgets**

This task was directed at elucidating a number of features about backwater areas. Backwater areas were specifically identified because of the widespread concern about the effects of continued sedimentation on these aquatic areas. Backwater areas were to be identified and classified by their hydraulic connection to the main channel. Detailed investigations, including two-dimensional hydraulic modeling, suspended sediment budgets, and sedimentation rates, were also identified as major information needs.

The Corps' navigation study developed a GIS database identifying backwater areas and characterizing their hydraulic connection to the main channel (WEST Consultants, Inc. 2000). Sedimentation rates in selected backwaters have also been studied (Rogala et al. 1997). Two backwater areas, Weaver Bottoms (Anderson et al. 1999) and Peterson Lake (J. Hendrickson, St. Paul District, U.S. Army Corps of Engineers, St. Paul, Minnesota, personal communication), have been intensively studied and sediment budgets have been developed.

The second working group recommended that a more detailed geomorphological analysis of backwater areas be conducted. They envisioned the use of preimpoundment elevation data (where available) to develop information on the change in elevation since impoundment. This would allow for mapping areas of sediment accumulation. The working group also suggested that a rigorous review of aerial photographs would provide insight into ongoing processes and could aid in forecasting river conditions. This process would support the development of a relatively simple transition matrix that could document past changes in geomorphological features and provide some estimation of future trends.

### **Task 9. Synthesis and Estimation of Future Configuration of Upper Mississippi River System Channels and Floodplain**

This task was originally proposed to be a synthesis of the information provided by the previous tasks and was envisioned to forecast the configuration of the channels and floodplains of

the UMRS over the next 50 years. The Cumulative Effects Report (WEST Consultants, Inc. 2000), developed as part of the Corps' navigation study, was seen by the second working group as a first approximation in meeting the information needs for this task.

The second working group also recommended the development of a systems model with sufficient resolution to predict pool-scale changes in morphology. Further, more "tailored" models could be developed for specific areas of the river.

### **Summary of Working Group Recommendations**

1. The LTRMP should consider serving a role as data curator for non-LTRMP data related to sediments, sedimentation, and geomorphology of the UMRS.
2. Floodplain elevation data remains a critical information need that should receive high priority within LTRMP.
3. Greater use of elevation transects should be made to document sedimentation rates in backwater areas.
4. A qualitative system model should be developed to address sediment issues.
5. Data should be acquired to support the development of a geospatial database of bed material.
6. Further research on bed material transport is urgently needed.
7. A more detailed geomorphological analysis of backwater areas should be conducted and used to develop a transition matrix to estimate future geomorphology.
8. A systems model should be developed with sufficient resolution to estimate pool-scale changes in morphology.

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## Appendix

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, D.C. 20503			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE  September 2002	3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE Recommended Investigations of Sediment Transport and Deposition for Predicting Future Configurations of UMRS Channels and Floodplain		5. FUNDING NUMBERS	
6. AUTHOR(S) Robert F. Gaugush <sup>1</sup> and Daniel B. Wilcox <sup>2</sup>			
7. PERFORMING ORGANIZATION NAME AND ADDRESS <sup>1</sup> U.S. Geological Survey, Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, Wisconsin 54603; <sup>2</sup> U.S. Army Corps of Engineers, St. Paul District, 190 Fifth Street East, St. Paul, Minnesota 55101.		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Geological Survey, Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, Wisconsin 54603		10. SPONSORING/MONITORING AGENCY REPORT NUMBER  2002-P001	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT  Release unlimited. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650). Available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Reviews the progress made in the study of sediment transport and geomorphology in the Upper Mississippi River System since the 1994 meeting of the working group that developed a description of activities needed. Identifies the work performed in the prescribed tasks and describes additional work to be performed, in particular the research and monitoring by the Long Term Resource Monitoring Program and the U.S. Army Corps of Engineers.			
14. SUBJECT TERMS Geomorphology, backwater, floodplain, hydraulic, monitoring, sediment transport.		15. NUMBER OF PAGES  5 pp + Appendix	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE  Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified Unclassified	20. LIMITATION OF ABSTRACT